Forecasts of Denitrifying PSCs for SOLVE-2

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Plan:
Apply modelling approach used to analyse PSCs during the SOLVE winter [*Drdla et al.*, *JGR*, 2002] to forecasting the SOLVE-2 winter

Outline:
1) Key aspects of the model
2) Sample forecast products
3) PSC formation so far this winter

IMPACT Model

"Integrated MicroPhysics and Aerosol Chemistry on Trajectories"

Full microphysics model with PSCs, heterogeneous chemistry, and gas-phase chemistry

- Calculates full size distribution for each possible PSC type
- Processes include freezing, nucleation, competitive growth, evaporation, and sedimentation
- Mie optics code provides extinction and backscatter

Biggest problem: no consensus on processes that form PSCs

- Use multiple scenarios to explore range of proposed theories
- Determine regions where
  - PSCs are most likely to be present, or
  - Models can be most effectively tested

Focus on PSCs that cause denitrification (aka Type Ia PSCs)

Model Scenarios

Ice Freezing Only

IceFrz: $T<T_{ice}$ (synoptically) necessary for NAT PSCs
i.e.: Waibel et al. [*Science*, 1999]

Homogeneous freezing to NAT (NAD)

- Freezing occurs in a "freezing belt" ($-8K < T-T_{NAT} < -5K$)
  [Tabazadeh et al., *Science*, 2001]

SalcFrz: Freezing rates of Salcedo et al. [*JPC A*, 2001]

SurfFrz: Faster freezing rates from Tabazadeh et al. [*JPC A*, 2002]

Heterogeneous freezing to NAT (NAD)

HetFrz: 0.02% of particles freeze at $T-T_{NAT} = -1K$

MetFrz: Meteoritic material [Cziczo et al., *Science*, 2001]
promotes temperature-dependent freezing
Parameters tuned to match SOLVE winter

MISSING: Leewaves (at least at current time...)

Trajectory dataset

Large dataset of trajectories created to fill the vortex horizontally and vertically

- Isentropic trajectories calculated using NCEP 1×1 analyses
- First set initialized to fill vortex (200km×200km×25K) on Dec. 1st
  - 475 to 750 K
  - 9595 total trajectories
- Additional set will be initialized on Jan. 1st

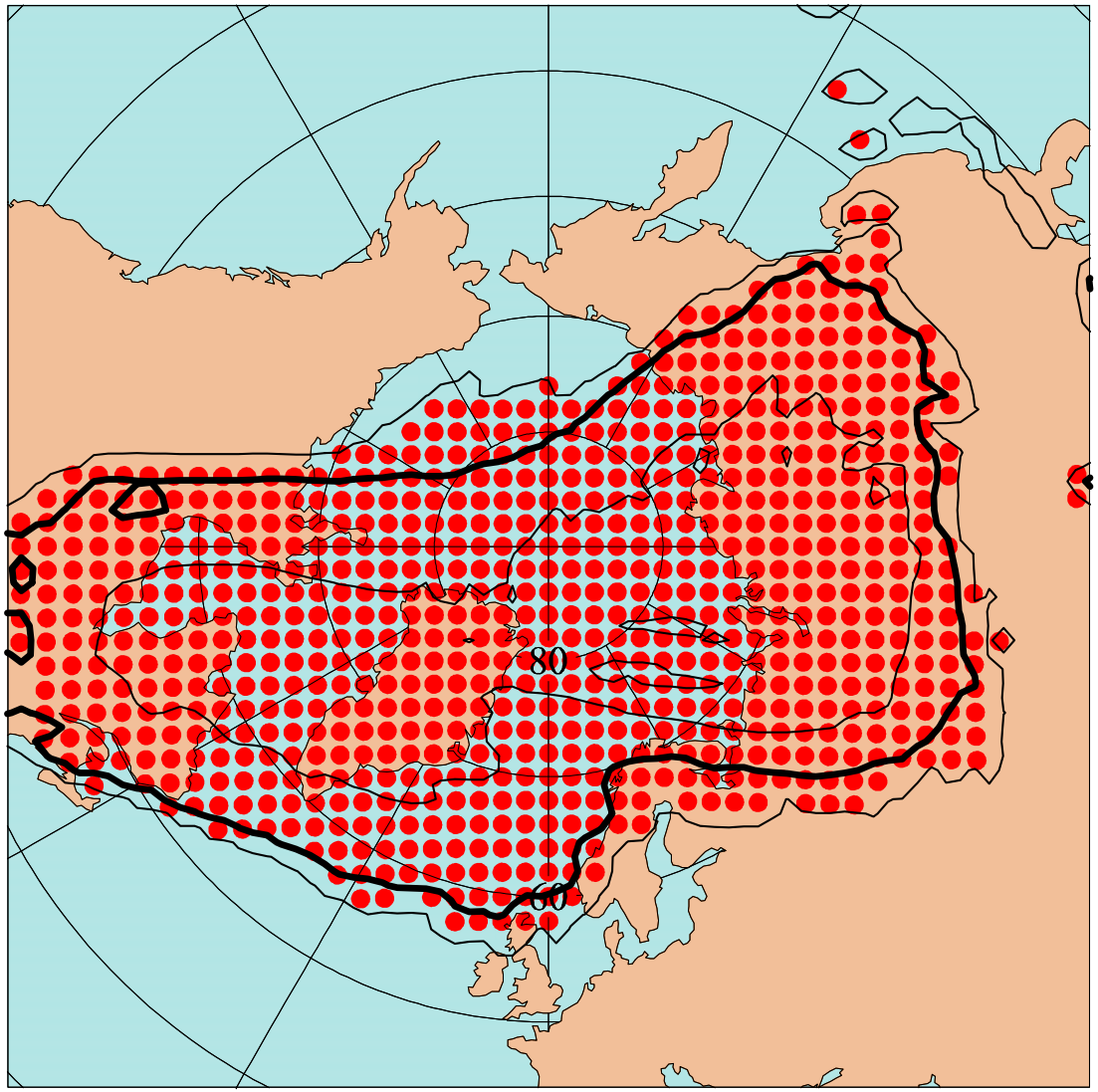
All trajectories followed from Nov. 15th onwards, regularly updating with newest analyses

- 120 hour NCEP forecasts provide forecast trajectories

Note: Each trajectory is modelled separately

- Allows resolution to be decreased for rapid simulations, or increased in specific regions of interest

Trajectory Initialization on 20021201 at 500 K



Planned Forecast Products

(Feedback welcome!)

1) Maps of PSC location and denitrification

- maps on every theta surface where PSCs are present
- summary maps integrating all theta surfaces

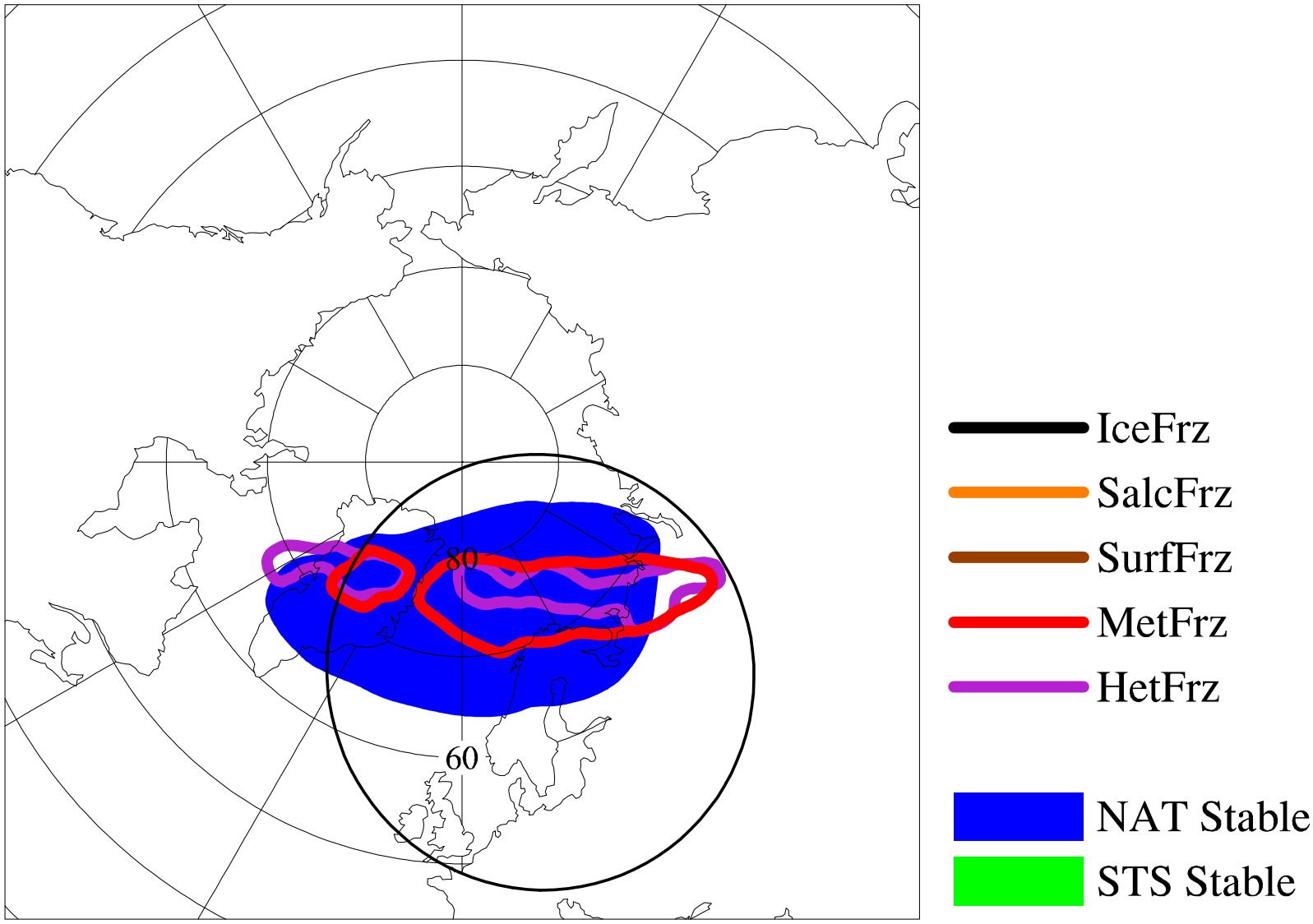
2) Profiles at representative locations

- extinction, denitrification rate

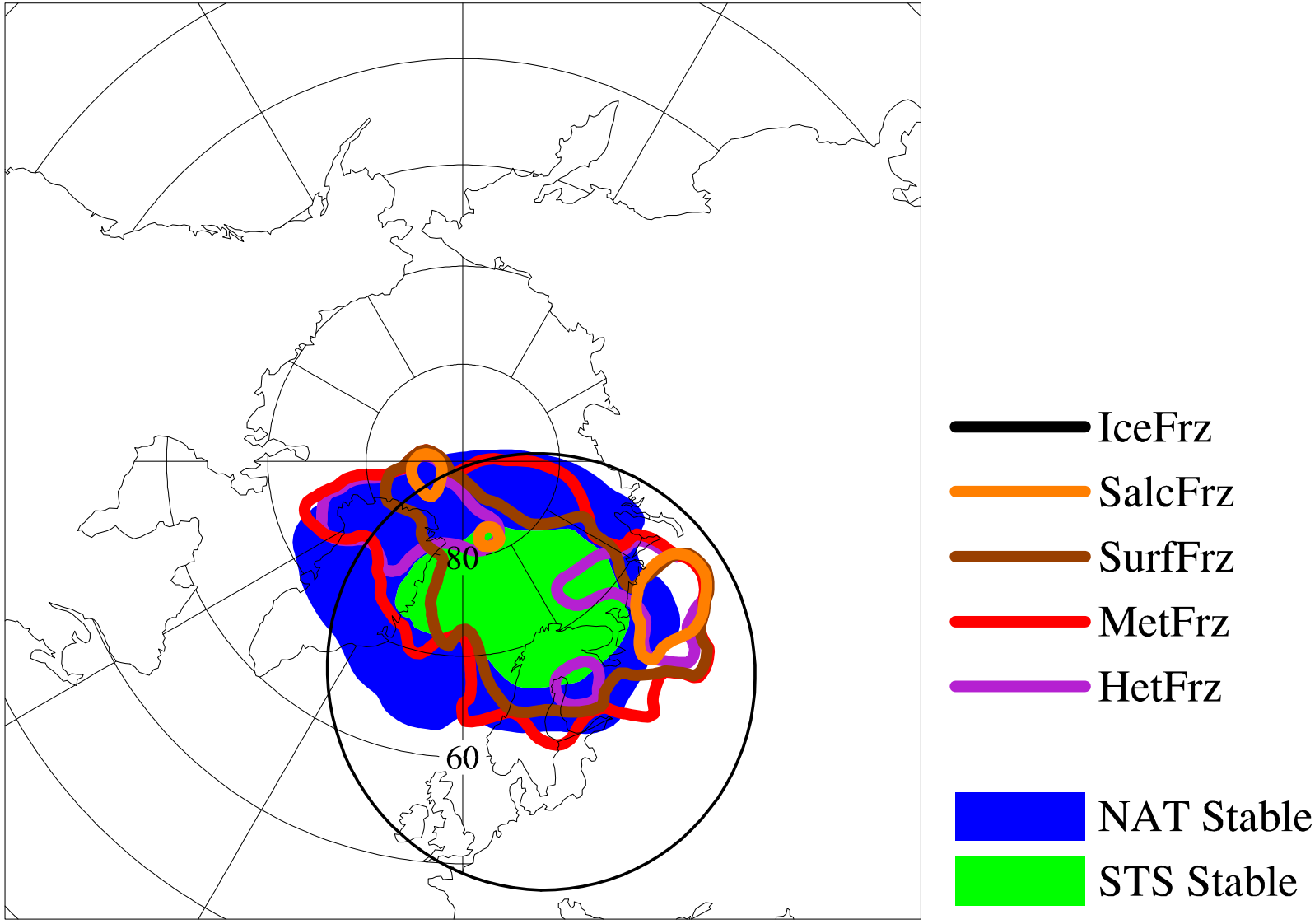
Other model products, available upon request, include:

- backscatter
- dehydration
- chlorine activation
- ozone loss

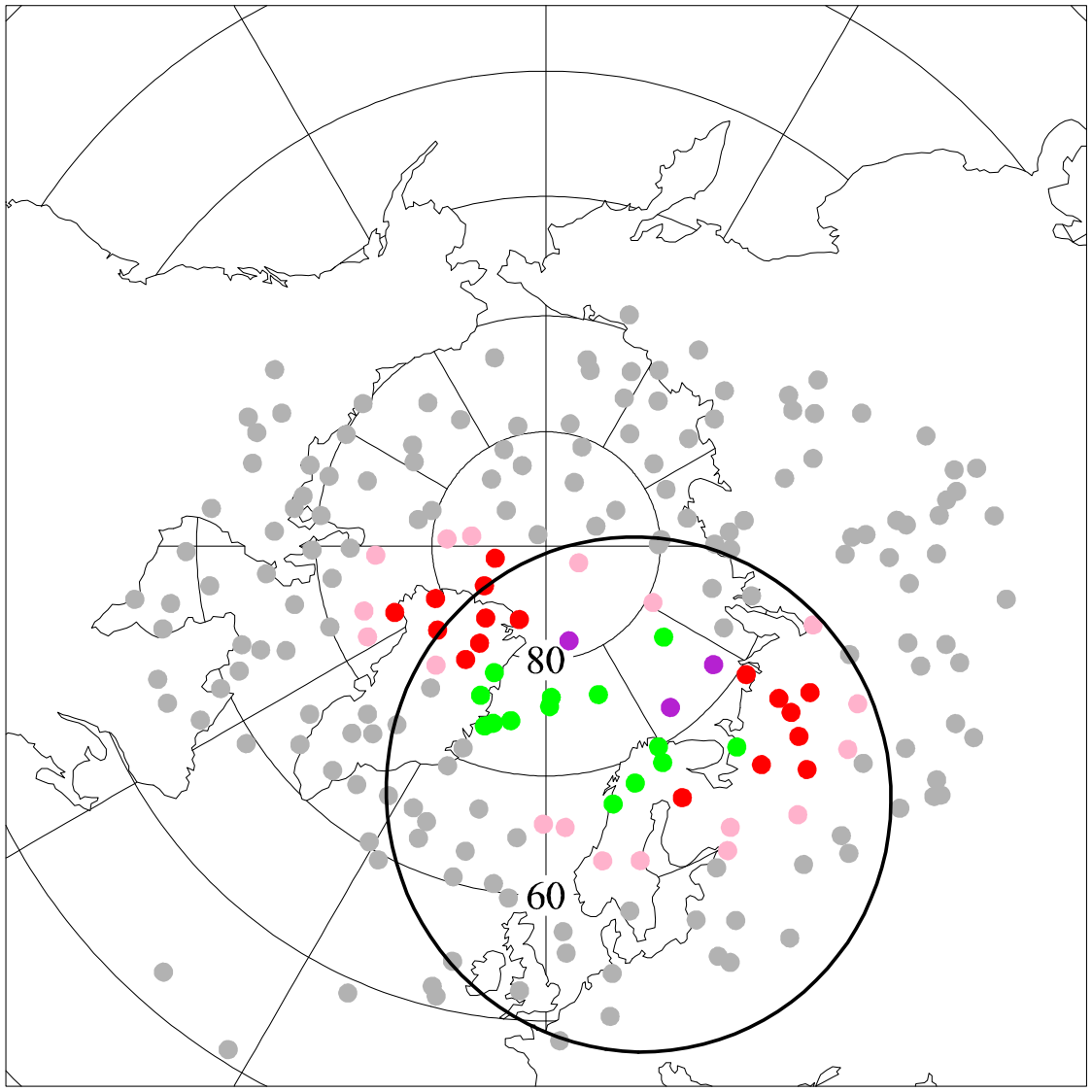
PSC Regions at 525 K on 02120212



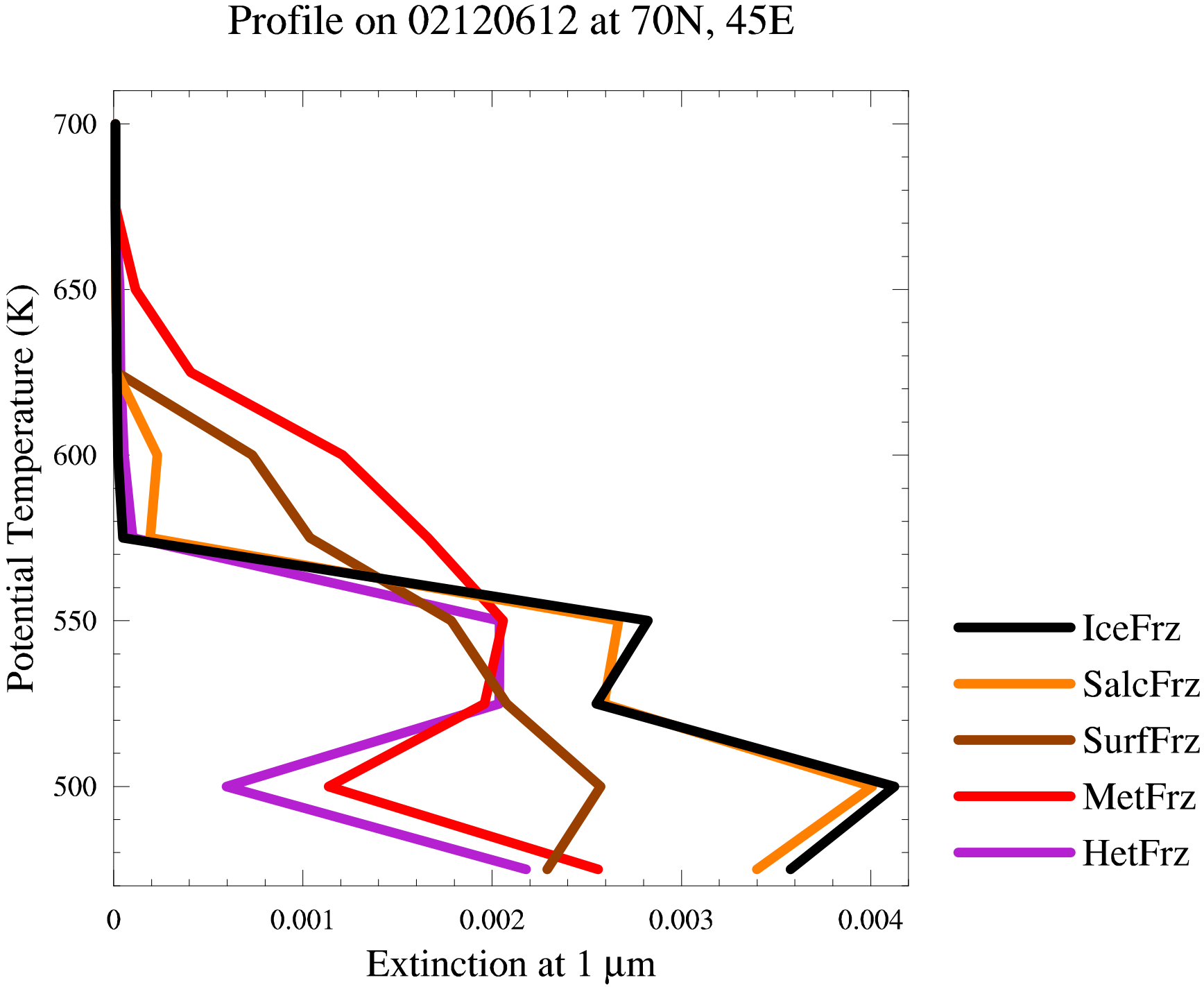
PSC Regions at 525 K on 02120612

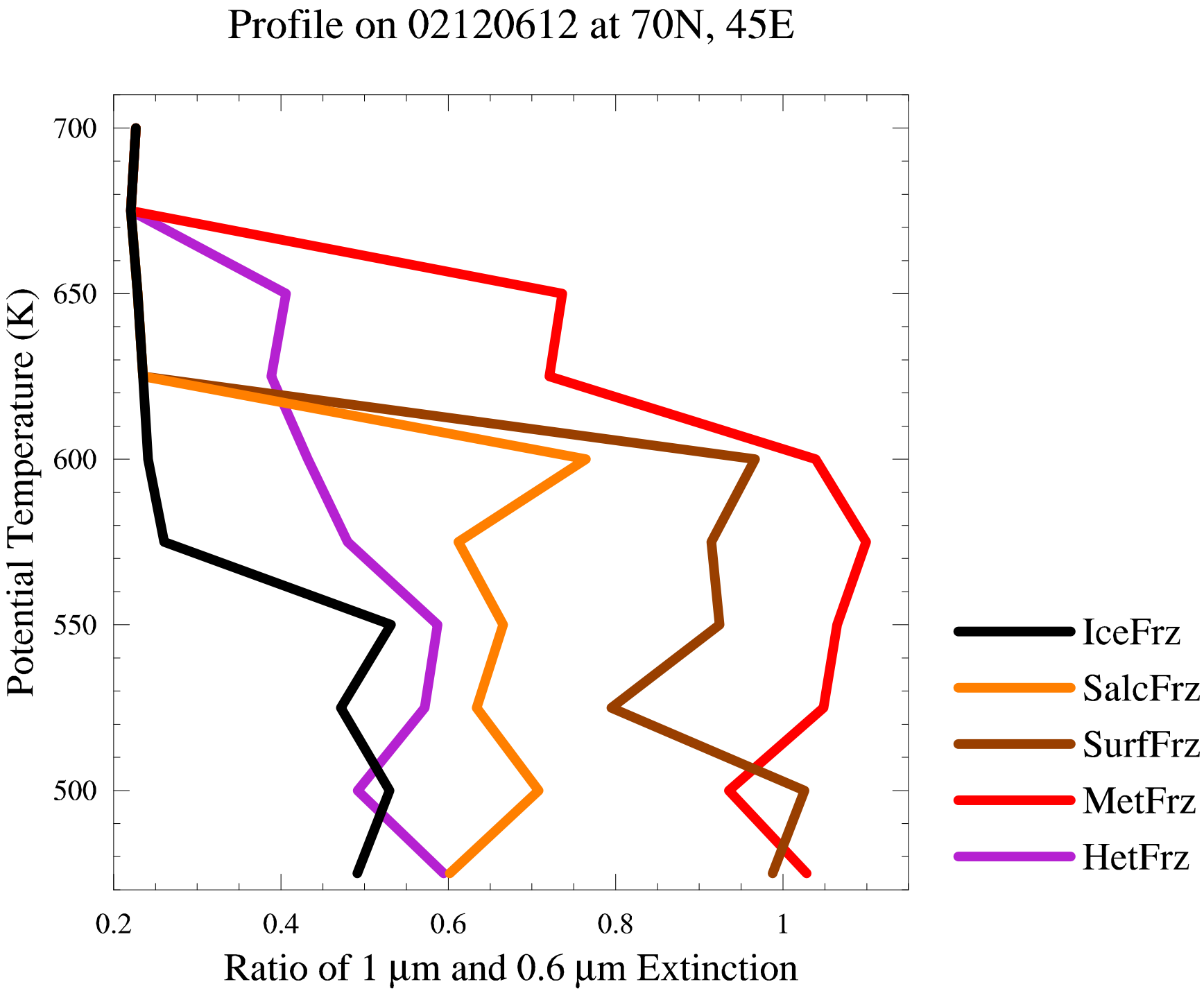


HetFrz PSCs at 525 K on 02120612

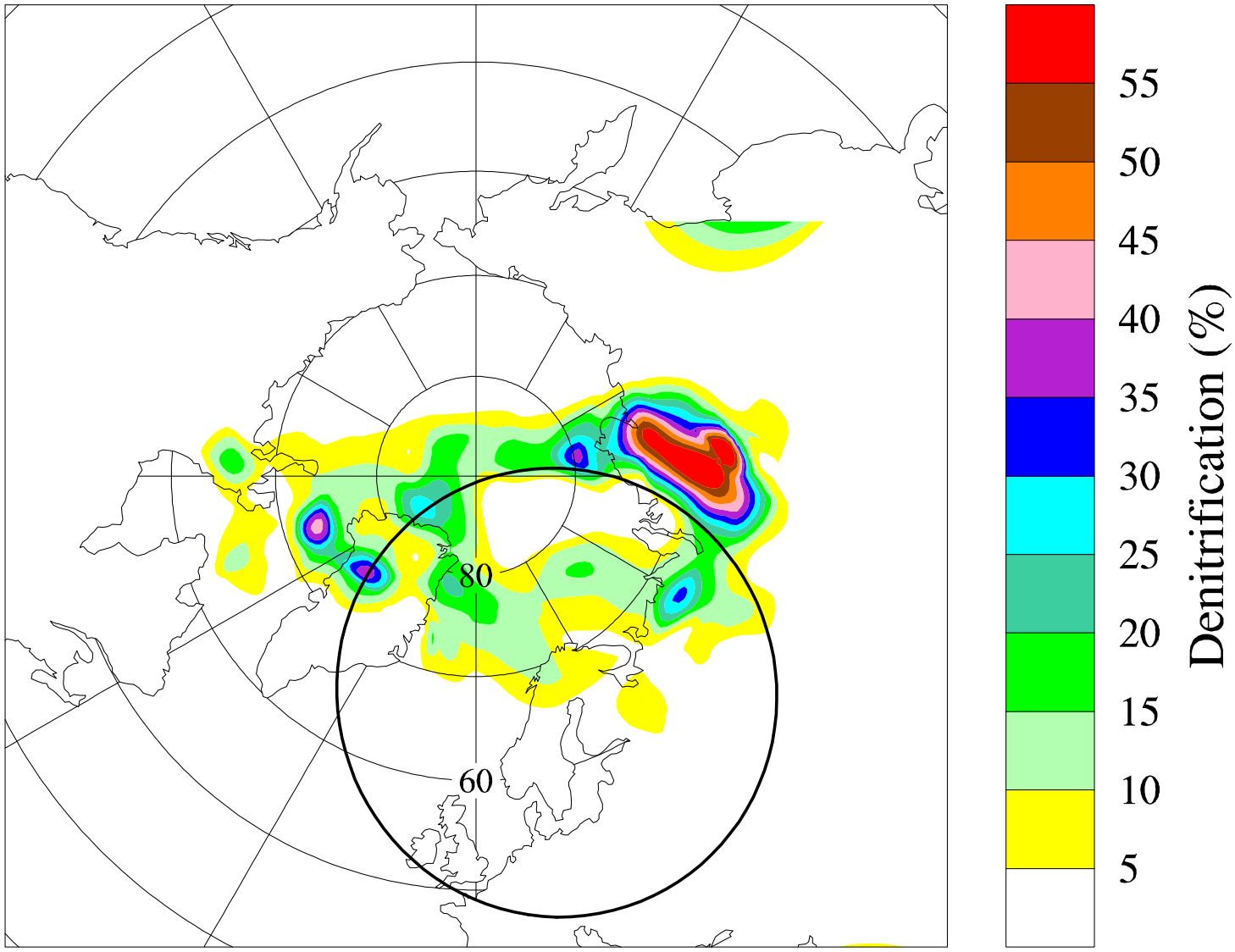


No PSCs
Trace STS
Trace NAT
STS PSCs
Mixed PSCs
NAT PSCs

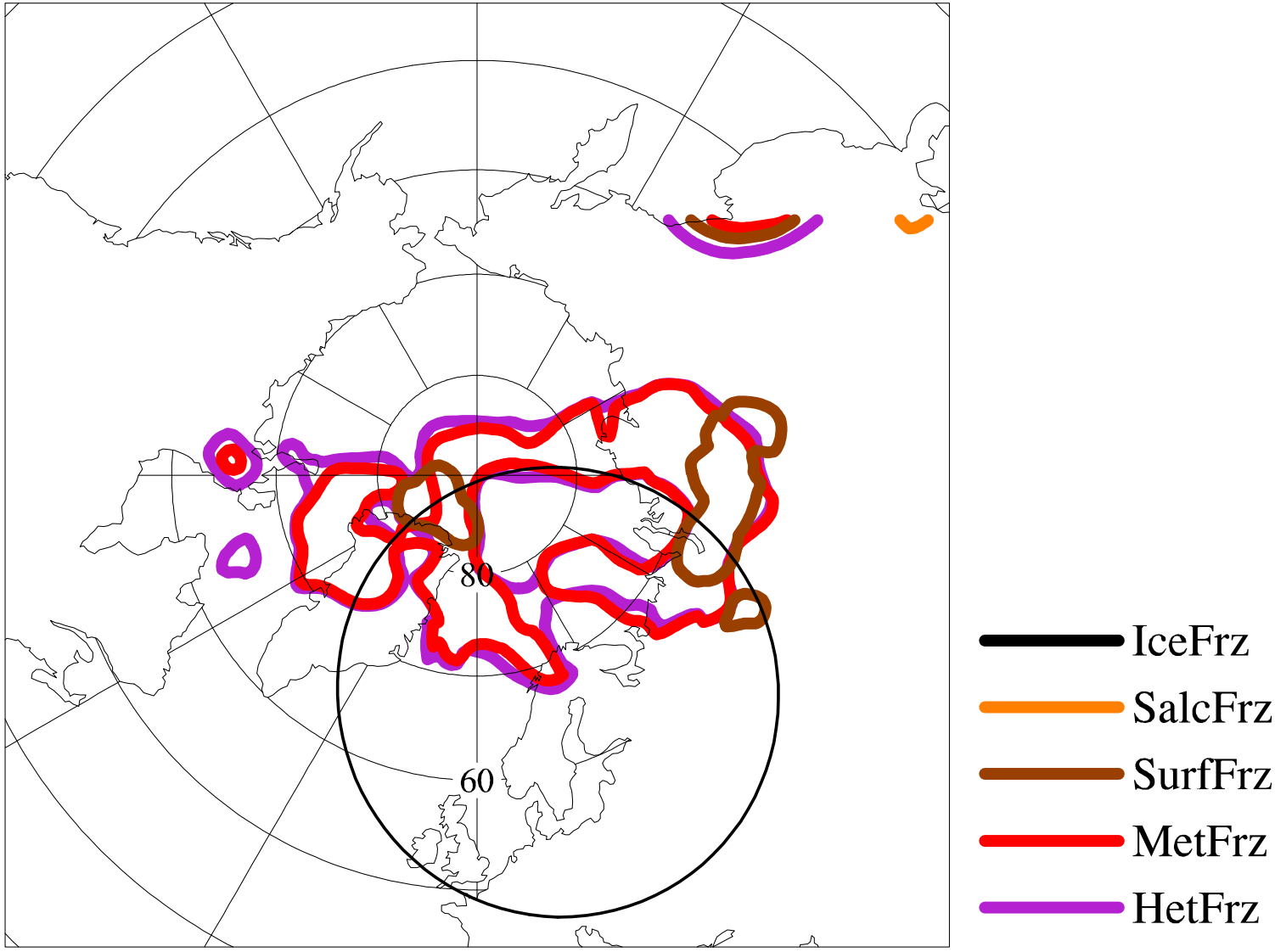

Profile on 02120612 at 70N, 45E
Potential Temperature (K)
700
650
600
550
500
0
0.001
0.002
0.003
0.004
Extinction at 1 µm
IceFrz
SalcFrz
SurfFrz
MetFrz
HetFrz


Profile on 02120612 at 70N, 45E
Potential Temperature (K)
700
650
600
550
500
0.2
0.4
0.6
0.8
1
Ratio of 1 µm and 0.6 µm Extinction
IceFrz
SalcFrz
SurfFrz
MetFrz
HetFrz

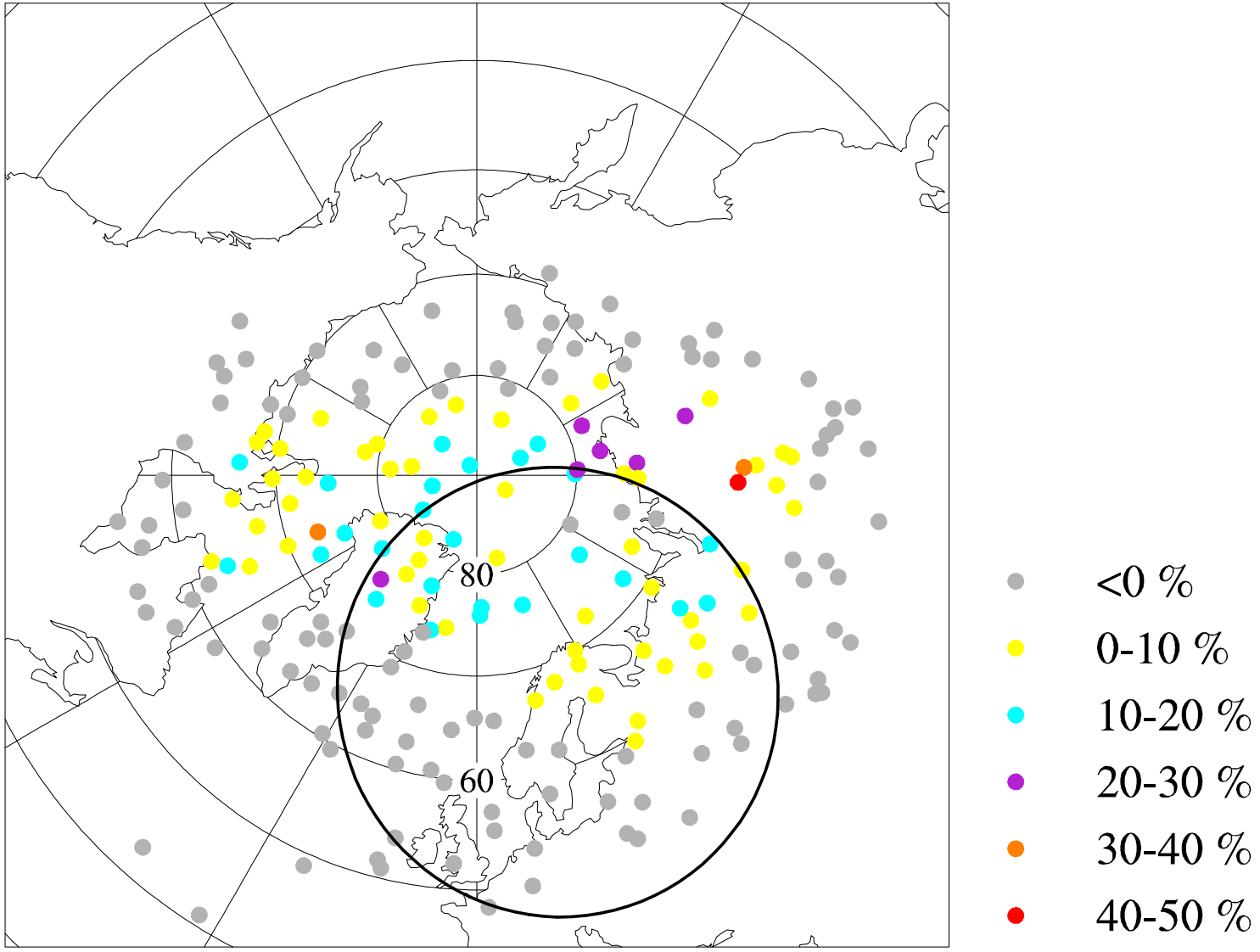
Maximum Denitrification at 525 K on 02120612

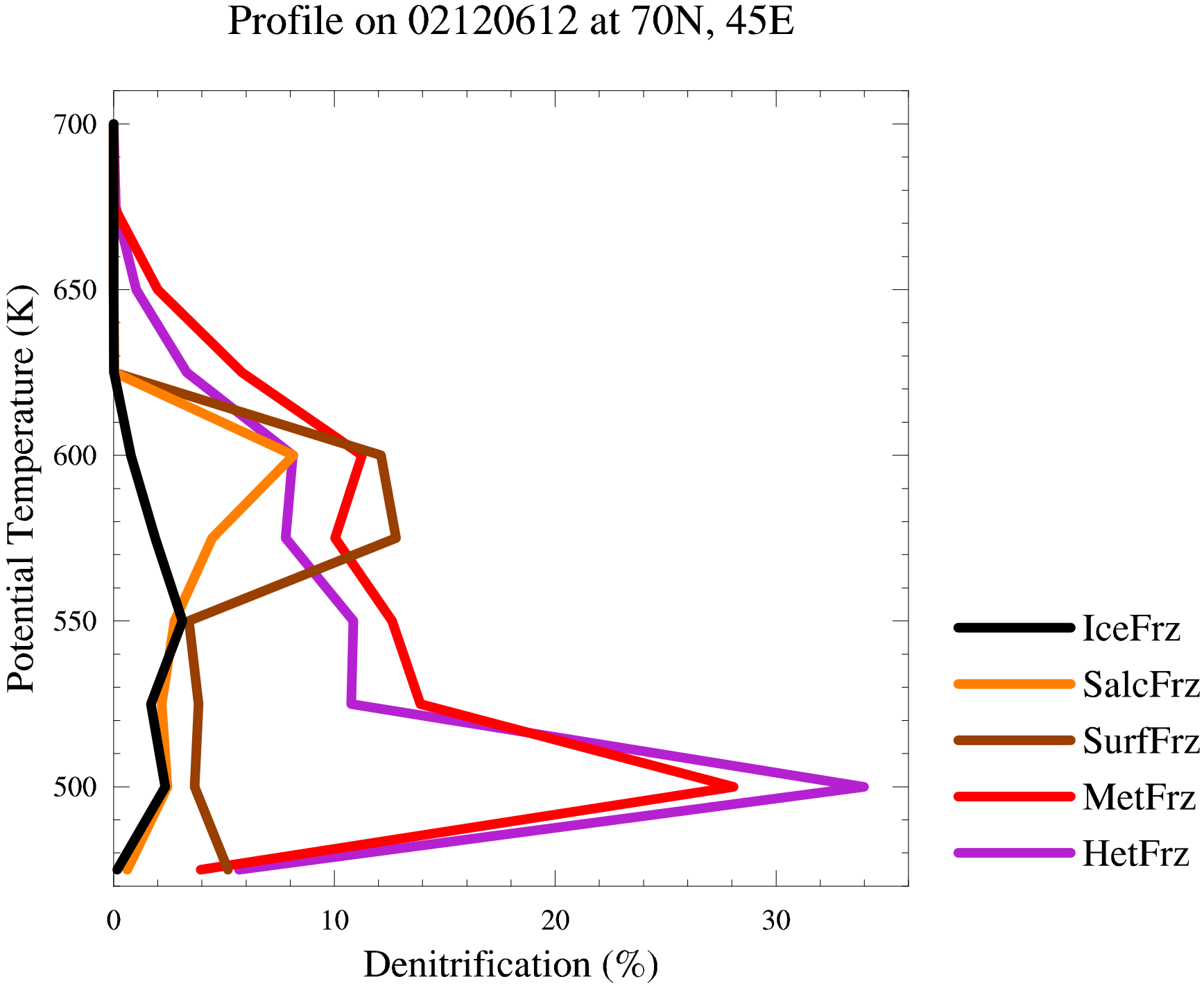


Denitrified Regions at 525 K on 02120612

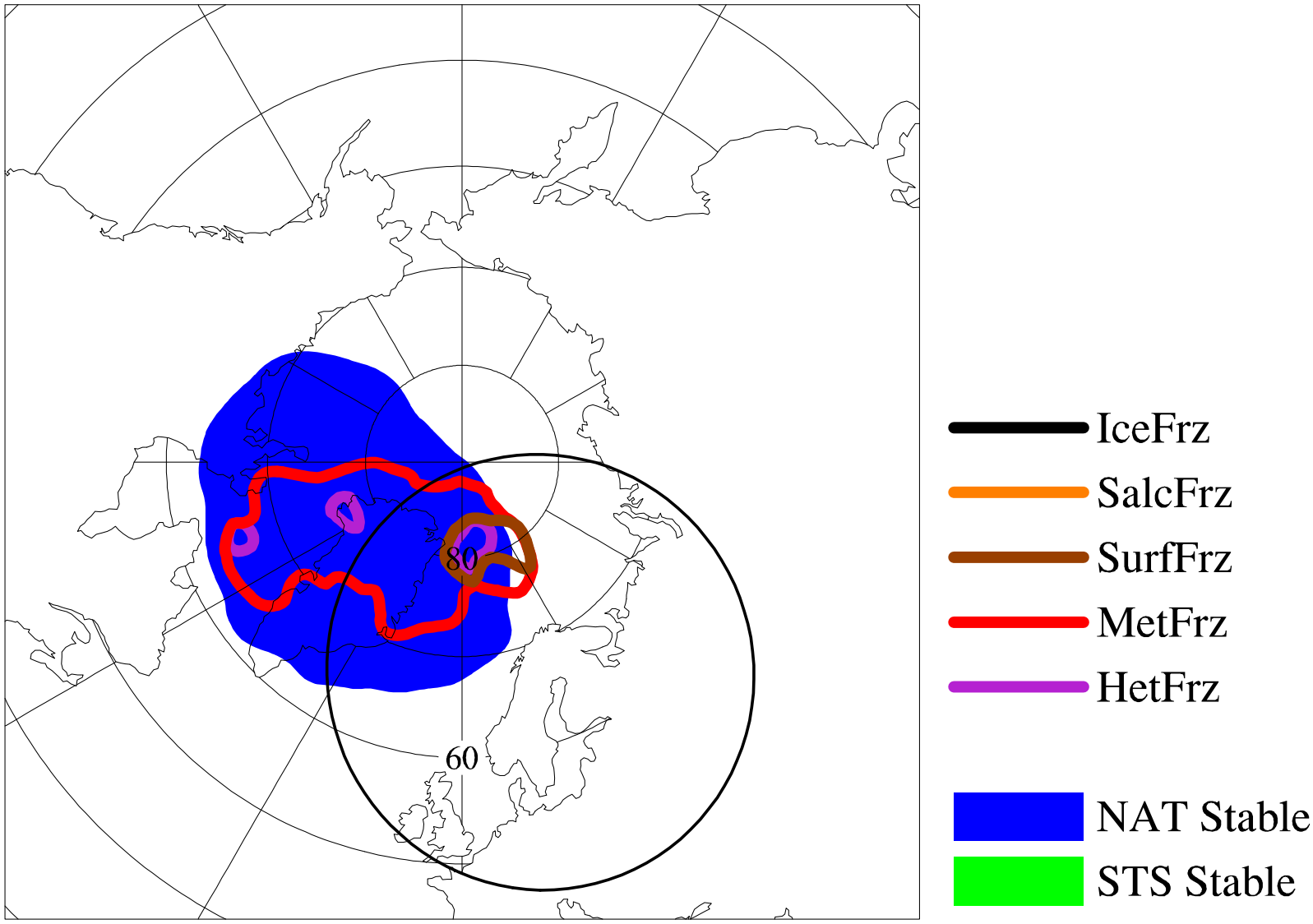


HetFrz Denitrification at 525 K on 02120612

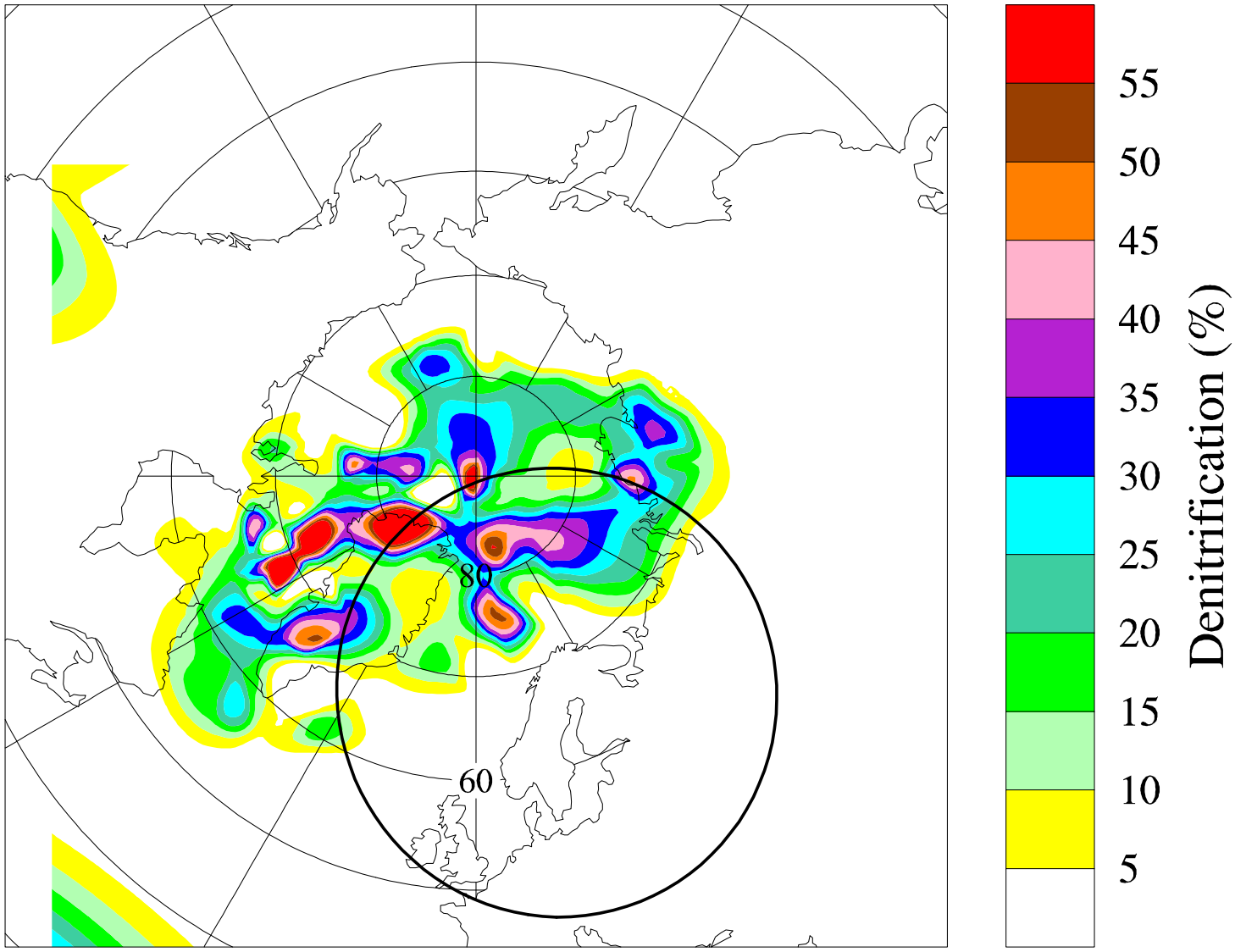



Profile on 02120612 at 70N, 45E
Potential Temperature (K)
700
650
600
550
500
0
10
20
30
Denitrification (%)
IceFrz
SalcFrz
SurfFrz
MetFrz
HetFrz

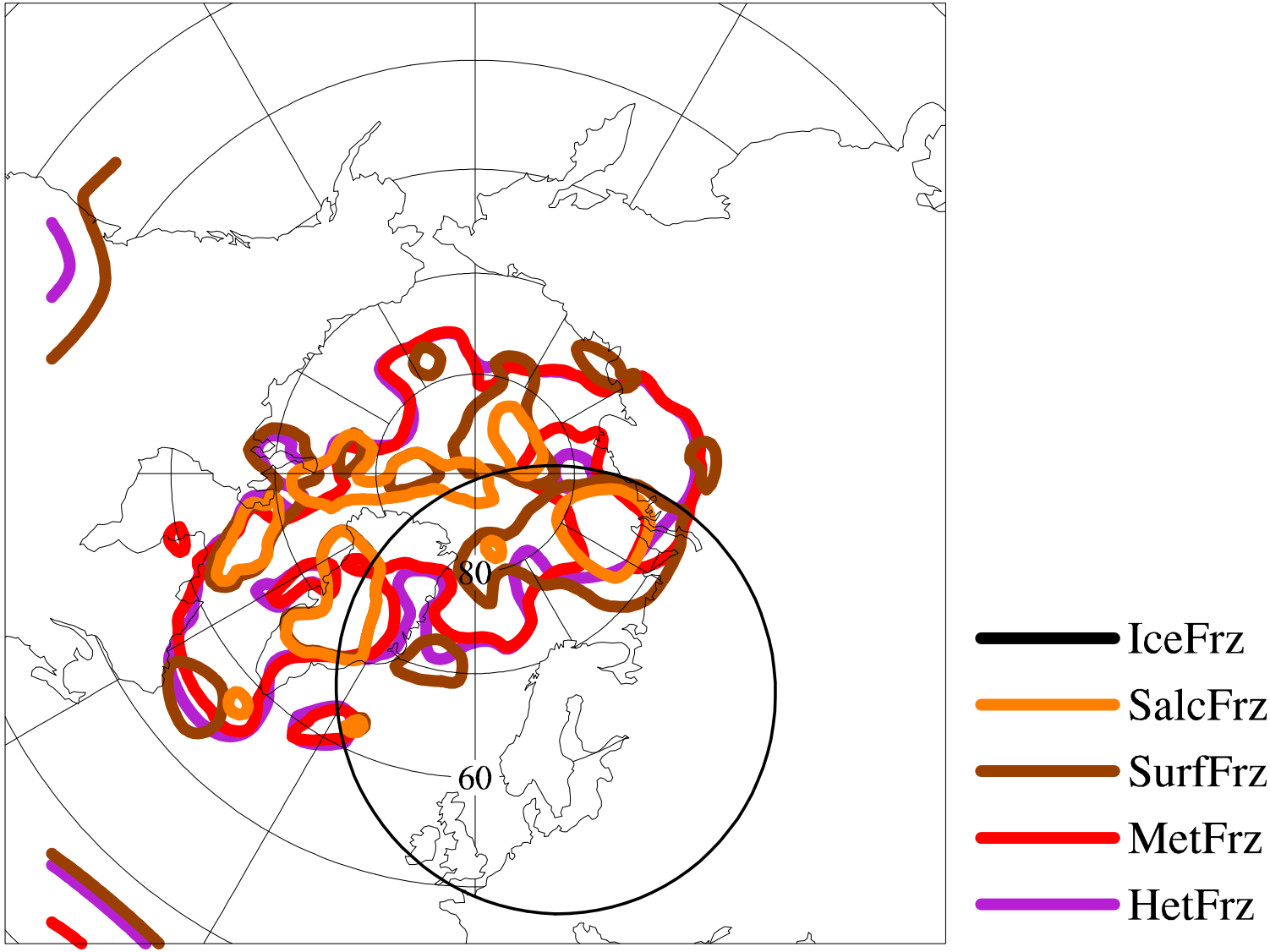
PSC Regions at 550 K on 02121312



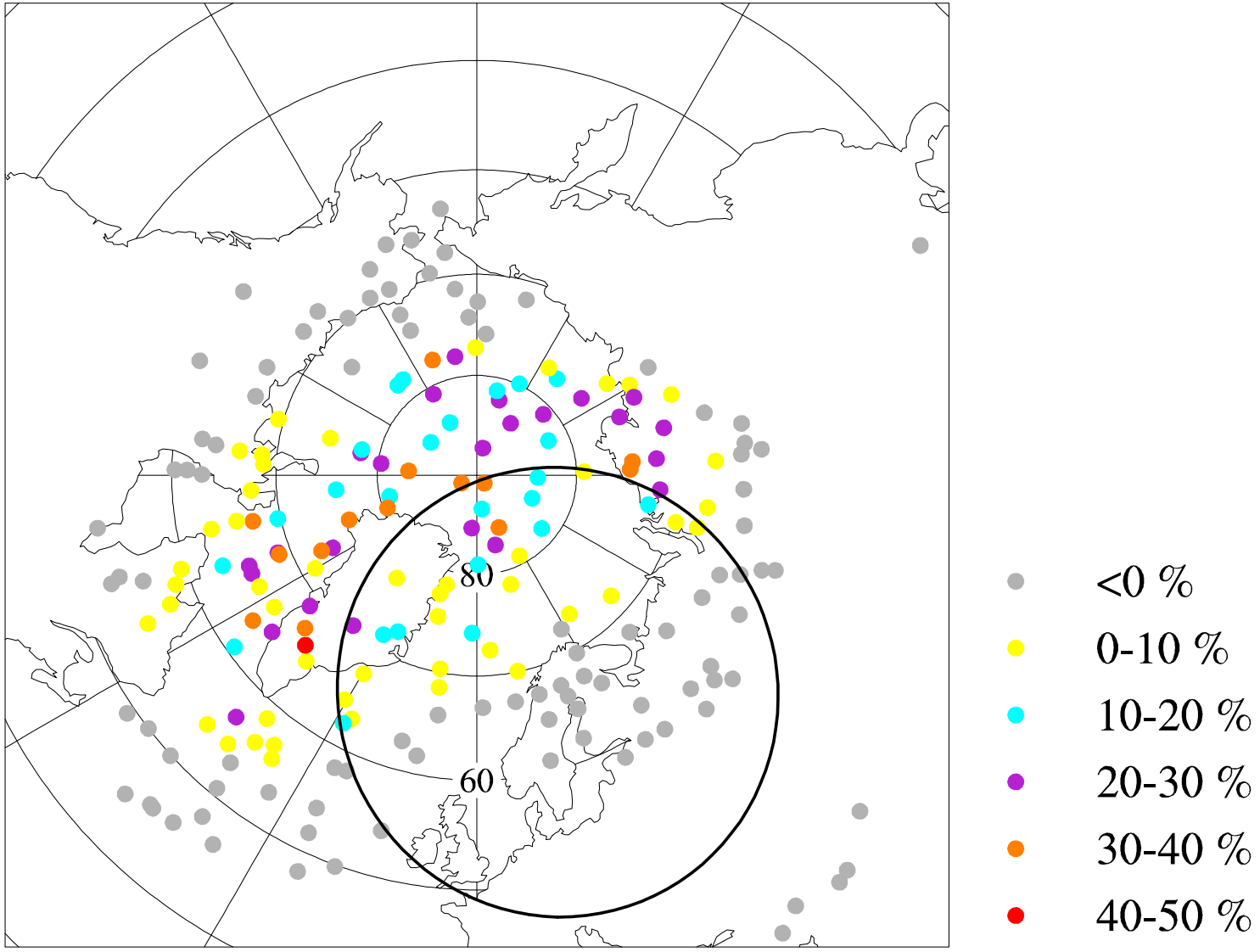
Maximum Denitrification at 550 K on 02121312

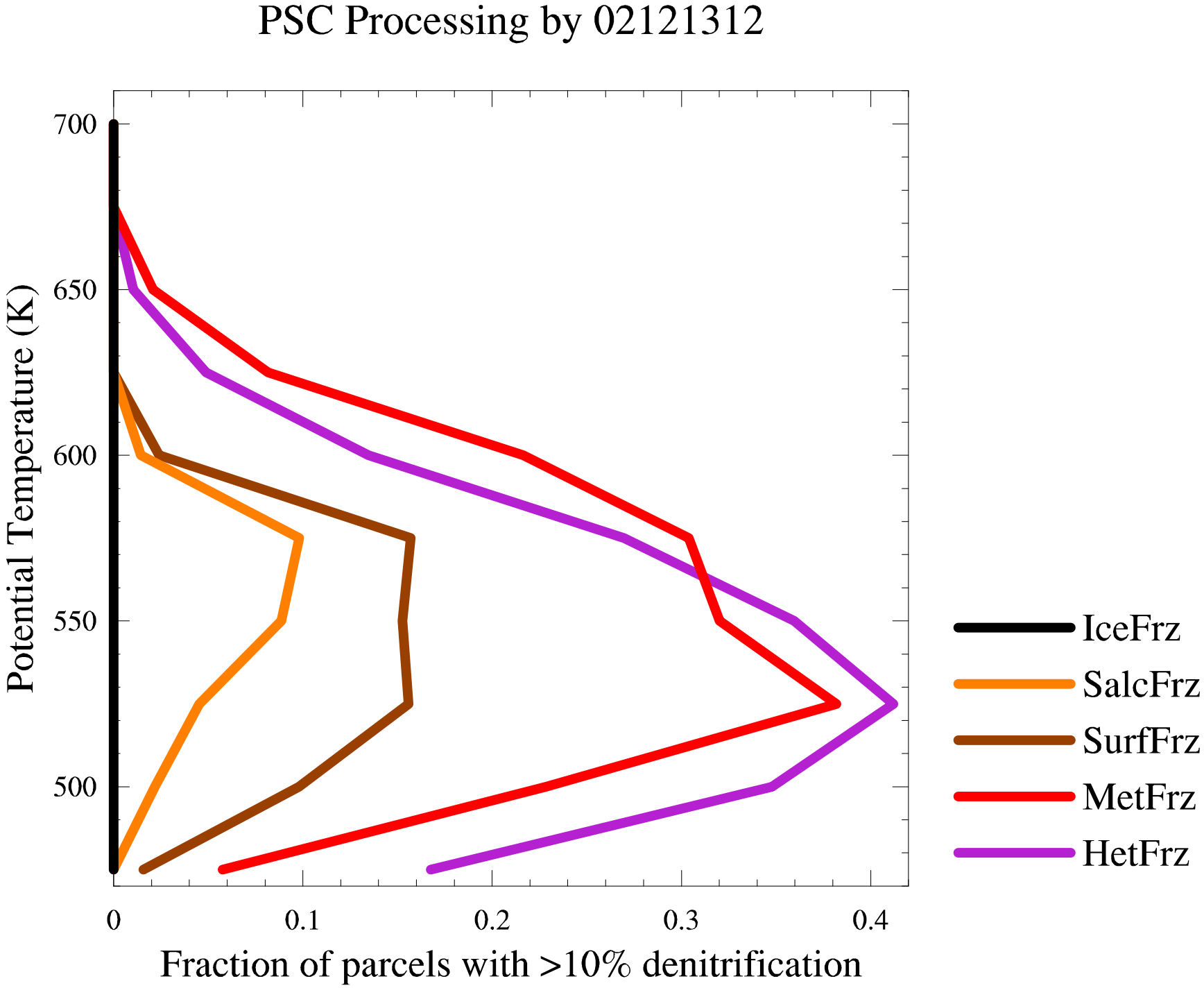


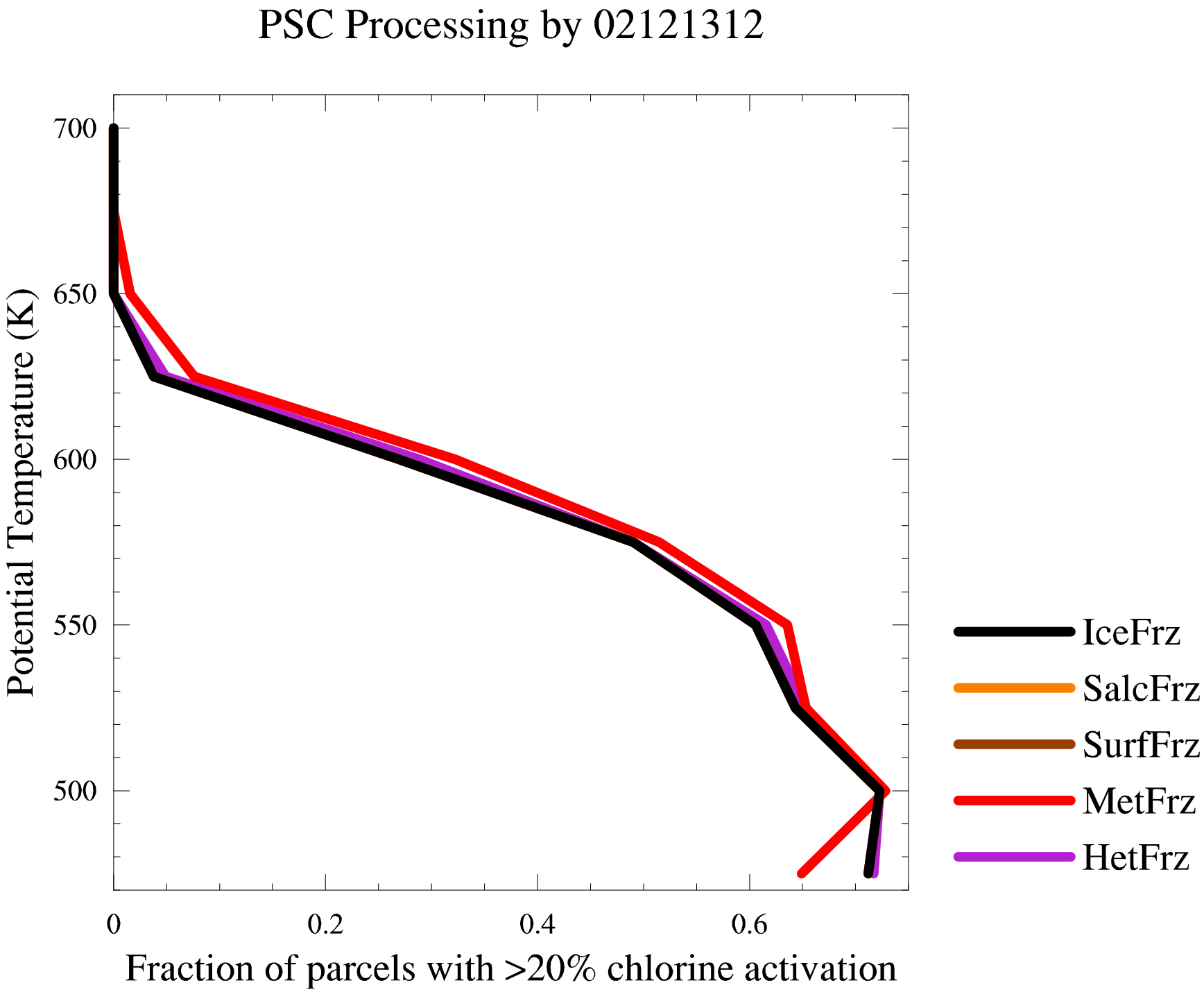
Denitrified Regions at 550 K on 02121312



HetFrz Denitrification at 550 K on 02121312




PSC Processing by 02121312
Potential Temperature (K)
700
650
600
550
500
0
0.1
0.2
0.3
0.4
Fraction of parcels with >10% denitrification
IceFrz
SalcFrz
SurfFrz
MetFrz
HetFrz


PSC Processing by 02121312
Potential Temperature (K)
700
650
600
550
500
0
0.2
0.4
0.6
Fraction of parcels with >20% chlorine activation
IceFrz
SalcFrz
SurfFrz
MetFrz
HetFrz

Summary

120-hour forecasts of PSCs will be available daily

- Provide PSC type, denitrification, and extinction, based on several different current theories of PSC formation
- Enable identification of regions where PSCs are most likely to be present, and regions that will best differentiate between the different PSC theories

Widespread PSC formation indicated already this winter

- PSC temperatures present at 475-550 K since Nov. 18th
- ~70% of vortex has activated chlorine
- ~40% of vortex may be denitrified by 10-50%

Will MkIV flight provide a pre-winter reference profile?
How will this processing affect conditions in January?